Geotechnical centrifuge permeameter for characterizing the hydraulic integrity of partially saturated confining strata for CSG operations

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Coal seam gas (CSG) and groundwater

Extraction of groundwater for CSG production is necessary to reduce the hydraulic head at the coal seam to enable gas desorption. Vertical hydraulic disconnection (or connection) through the overburden by low permeability confining strata (i.e. aquitards) can limit potential impacts of dewatering and contamination migration. Groundwater flow through aquitards is typically very slow, but could be significant at regional scale over long periods of time. Argillaceous materials can form effective aquitards provided that there is no loss of hydraulic integrity due to faults or geological structures, and where they are resistant to stress fractures from drilling and fraccing.

Geotechnical centrifuge technology

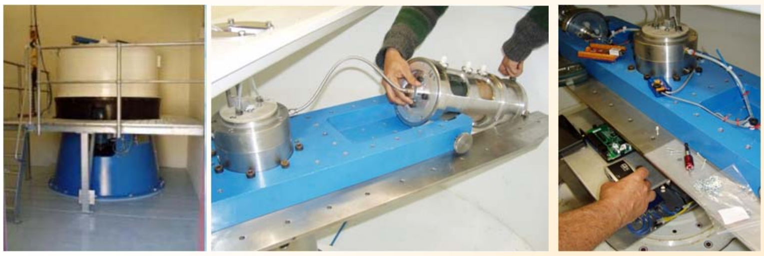

Figure 1. UNSW-NCGRT geotechnical centrifuge (left), and new permeameter module assembly (centre and right).

- Vertical hydraulic conductivity (K_v) measurements of tight aquitards are not practical and time-efficient using standard test methods (e.g. falling/constant head permeameters)
- Expedited determination of hydraulic integrity is possible using geotechnical centrifuge technology (e.g. accelerating intact core samples at 100 times gravity (G) makes it possible to observe in 1 day of centrifuge testing flow that would occur in ~ 27 years)
- UNSW geocentrifuge (Figure 1) is a Broadbent G-18 Geotechnical Centrifuge (2m diameter) with new centrifuge permeameters (2 x 4.7kg permeameter sample at 556 G-max)
- Centrifuge permeameters designed for groundwater research, allowing for on-board instrumentation and real-time monitoring of a range of parameters

Experimental setup

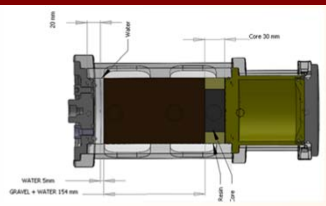

Figure 2. Section view of core setup in permeameter module

- Intact shale overburden core (65-80 mm diameter) tested from the Surat Basin (> 500 m depth)
- Core assumed to be fully saturated (in synthesised pore water) and moisture content determined before and after testing
- Rock core set in permeameter liners using ultra low permeability resin (Figure 2)
- K_v determined using method adapted from ASTM D6527-2000 using centrifuge permeameter (10-400 G)

Hydraulic conductivity of confining strata

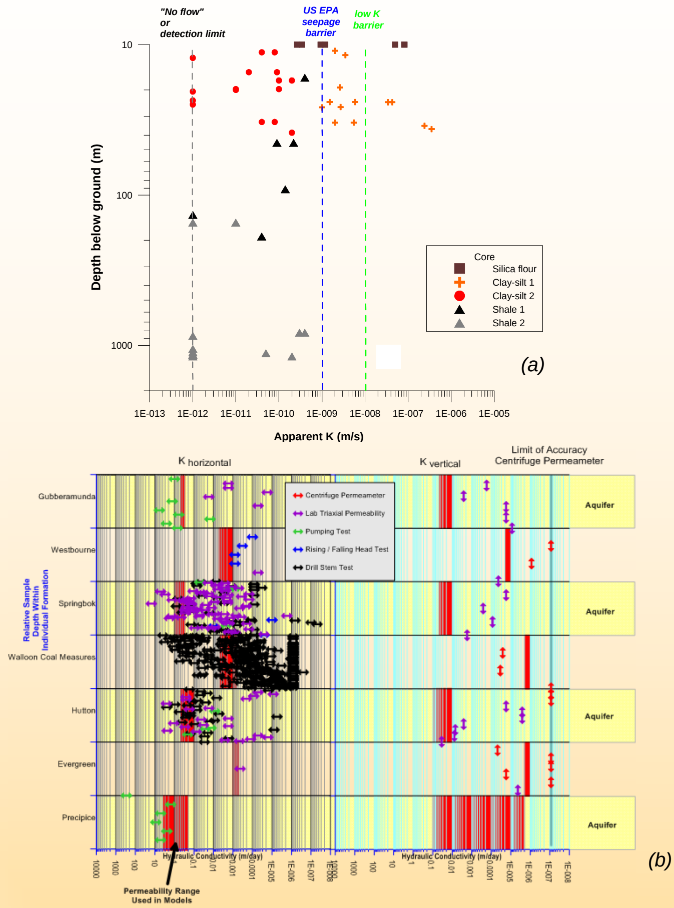

Figure 3. (a) Hydraulic conductivity as a function of depth of rock core samples (Shale 2) compared to more permeable matrix at steady state flow with geocentrifuge; (b) Summary of APLNG (2013) hydraulic conductivity tests, m/day (K_v and K_h, various laboratory and field techniques).

- K_v ranged from < 10^{-12} – $4x10^{-10}$ m/s (n=12), consistent with larger permeability datasets for shale, and at least 10-100 times lower than some alluvial clay aquitards (Figure 3)
- Current detection limit of <10^{-12} m/s was reached in half the tests, with up to 520 G necessary to force flow
- K_v is sensitive to moisture content (cores were not fully saturated) and small fractures due to defects in drill core
- New centrifuge instrumentation developments underway for real-time monitoring of moisture content under transient flow and partially saturated core conditions deriving K_v data of greater certainty for model inputs
- This will also allow determination of the extent to which vertical seepage is influenced during dewatering.

References

References for this poster are available in the full paper:

Bouzalakos S, Timms W, Rahman P, McGeeney D, Whelan M (2013). Geotechnical centrifuge permeameter for characterizing the hydraulic integrity of partially saturated confining strata for CSG operations. In: Wolkersdorfer, Brown and Figueroa (Editors) Reliable Mine Water Technology, Proceedings of the International Mine Water Congress, Colorado School of Mines, August 5-9, 2013, Vol II, p 1193-1198

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August, 2013